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Reliability and Sensitivity of the Foot and Ankle Disability Index in Subjects With Chronic Ankle Instability

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Context: Despite the importance of patient's subjective reports of function, little research has addressed their use in the athletic population.

Objective: To examine the following measurement properties of the Foot and Ankle Disability Index (FADI) and the FADI Sport: (1) intersession reliability during 1- and 6-week intervals, (2) sensitivity to differences between healthy subjects and subjects with chronic ankle instability (CAI), and (3) sensitivity to changes in function in those with CAI after rehabilitation.

Design: Test-retest design.

Setting: Laboratory setting.

Patients or Other Participants: Fifty recreationally active subjects.

Main Outcome Measure(s): FADI and FADI Sport.

Results: Intraclass correlation coefficients (ICC 2,1) for the FADI and FADI Sport at 1 week were 0.89 and 0.84, respectively, for the involved limbs. Over 6 weeks, the ICC values for the involved limb of subjects who did not complete rehabilitation were 0.93 and 0.92, respectively. For both surveys, scores were significantly less for the involved limbs of subjects with CAI compared with their uninvolved limbs ($P < .05$). No significant side-to-side differences were noted among the healthy subjects. Scores on both surveys increased significantly after rehabilitation (FADI: $P < .05$, effect size = 0.52; FADI Sport: $P < .05$, effect size = 0.71).

Conclusions: The FADI and FADI Sport appear to be (1) reliable in detecting functional limitations in subjects with CAI, (2) sensitive to differences between healthy subjects and subjects with CAI, and (3) responsive to improvements in function after rehabilitation in subjects with CAI.

Key Words: clinical outcome measure, self-report of function, functional scales

Lateral ankle sprains are one of the most common injuries among athletes and other young, active adults.[1–5] According to Brooks et al,[6] the incidence of lateral ankle sprain is approximately 1 per 10 000 people per day. Ankle sprains are commonly seen in sports that involve jumping and cutting and account for 15% to 45% of all sports injuries.[7–10] A reported 10% to 30% of these individuals with ankle sprains develop chronic ankle instability (CAI).[11,12] Despite the frequency of ankle instability, no widely accepted outcomes tool is available to measure ankle function.[13]

Clinical outcome measures in orthopaedics have traditionally focused on measuring impairments, such as range of motion and strength.[11,14] It is impairments that are often addressed by clinicians in setting goals and assessing progress. Clinicians often overlook the functional limitations and disability experienced by patients. Because functional limitations and disability are commonly most important to the patient, it is essential that clinicians quantify dysfunction at this level. Subjective reports of function completed by patients are becoming an important outcome measure for health care practitioners.[15–17] These measures enable clinicians to assess changes in functional limitations and disabilities after clinical interventions. The Foot and Ankle Disability Index (FADI) was designed to assess functional limitations related to foot and ankle conditions.[18]

Subjective reports of function are classified as generic or specific measures, which include condition-specific, population-specific, and patient-specific instruments. Generic measures identify overall health and wellness and are designed to be clinically meaningful across various populations, body parts, and diseases. In contrast, specific measures are intended to quantify dysfunction related to specific conditions or regional body parts.[19,20] The FADI is a region-specific self-report of function with 2 components.[13] The FADI was first described in 1999 by Martin et al[18]; it assesses activities of daily living, and the FADI Sport assesses more difficult tasks that are essential to sport (Table 1).

The Foot Function Index,[21,22] the Ankle Osteoarthritis Scale,[23] and the American Orthopedic Foot and Ankle Scale[24] are 3 examples of outcome measures specific to the foot and ankle. The Foot Function Index was developed for use among elderly individuals with rheumatoid arthritis. It comprises 23 items that measure pain, disability, and activity restriction. Scoring is based on a visual analog scale.[21,22] The Foot Function Index has been reported to be reliable, valid, and sensitive to change in subjects with rheumatoid arthritis.[21]

Table 1. Foot and Ankle Disability Index and Foot and Ankle Disability Index Sport Items*

Foot and Ankle Disability Index Items	Foot and Ankle Disability Index Sport Items
Standing	Running
Walking on even ground	Jumping
Walking on even ground without shoes	Landing
Walking up hills	Squatting and stopping quickly
Walking down hills	Cutting, lateral movements
Going up stairs	Low-impact activities
Going down stairs	Ability to perform activity with your normal technique
Walking on uneven ground	Ability to participate in your desired sport as long as you would like
Stepping up and down curves	
Squatting	
Sleeping	
Coming up on your toes	
Walking initially	
Walking 5 minutes or less	
Walking approximately 10 minutes	
Walking 15 minutes or greater	
Home responsibilities	
Activities of daily living	
Personal care	
Light to moderate work (standing, walking)	
Heavy work (push/pulling, climbing, carrying)	
Recreational activities	
General level of pain	
Pain at rest	
Pain during your normal activity	
Pain first thing in the morning	

*Subjects were given the following instructions: ''Please answer every question with one response that most closely describes your condition within the past week. If the activity in question is limited by something other than your foot or ankle, mark N/A.'' Subjects rate the activity as no difficulty at all (4 points), slight difficulty (3 points), moderate difficulty (2 points), extreme difficulty (1 point), unable to do (0 points), or N/A (not applicable). For pain related to the foot and ankle, subjects select no pain (4 points), mild (3 points), moderate (2 points), severe (1 point), or unbearable (0 points). The Foot and Ankle Disability Index scores are recorded as a percentage of 104 points. The Foot and Ankle Disability Index Sport scores are recorded as a percentage of 32 points.

Domsic and Saltzman[23] modified the Foot Function Index to be used in patients with osteoarthritis and described the resulting scale as the Ankle Osteoarthritis Scale. This scale was reported to be both reliable and valid when used for measuring symptoms and disability among subjects with ankle osteoarthritis.[23]

The American Orthopedic Foot and Ankle Scale was designed for use among all patients with foot or ankle dysfunction. It comprises 4 region-specific scales, including ankle-hindfoot, midfoot, hallux metatarsophalangeal, and lesser metatarsophalangeal-interphalangeal scales. The patient records information regarding pain and function in each region. This scale also incorporates physical examination results recorded by the clinician.[24] Although the American Orthopedic Foot and Ankle Scale has been widely used in studies of foot and ankle surgical outcomes, limitations have also been reported.[16,25]

A more general scale, the Lower Extremity Functional Scale, was developed to be used for a wide range of patients with lower extremity orthopaedic conditions. This scale was developed based on the World Health Organization's model of disability and handicap. It comprises 20 items, and each item is scored by the subject as 0 (unable to perform) to 4 (no difficulty). The researchers who designed this scale also reported it to be reliable and valid in patients with lower extremity musculoskeletal conditions. It was more sensitive to change than the 36-item Short-Form Health Survey, a generic health status measure.[26]

The FADI Sport is unique in that it is a population-specific subscale designed for athletes. Many subjective reports of function are designed to be used among older populations or populations with limitations in the performance of activities of daily living.[21–24,26] When such scales are used in athletic populations, we observe a ceiling effect: athletes score at the extreme high end of normal function. This, in turn, decreases the sensitivity of the scale to functional deficits and treatment effects.[26] Therefore, population-specific subjective reports of function are needed. Despite a vast amount of research related to the development of outcome measures in older and more frail populations, few researchers have addressed the use of outcome measures in the athletic population.[27]

The FADI Sport is designed to address this need by detecting deficits in higher functioning subjects. However, few investigators have focused on establishing the psychometric properties of the FADI or FADI Sport. Our purposes were to examine the following measurement properties of the FADI and the FADI Sport: (1) intersession reliability during 1-week and 6-week intervals, (2) sensitivity to differences between healthy subjects and subjects with CAI, and (3) responsiveness to changes in function scores in those with CAI after rehabilitation.

METHODS

Subjects

Fifty (21 males and 29 females, 19 healthy and 31 with CAI) recreationally active subjects (age, 21.53 ± 3.59 years; height, 170.35 ± 11.50 cm; mass, 72.94 ± 19.32 kg) volunteered to participate in this study. Before participating, all sub-

Table 2. Outline of the Rehabilitation Program

Task	Progression	Home Program or Supervised Rehabilitation
Range of motion		
Gastrocnemius stretch		Both
Soleus stretch		Both
Strengthening		
Bipedal calf raise	Single leg	Both
Thera-Band* resistance	Resistance, repetitions	
Dorsiflexion		Both
Plantar flexion		Both
Inversion		Both
Eversion		Both
Plantar flexion, inversion		Both
Plantar flexion, eversion		Both
Dorsiflexion, inversion		Both
Dorsiflexion, eversion		Both
Neuromuscular control		
Single-leg stance	Eyes open versus closed, time, perturbation	Both
Single-leg stance ball toss	Time, surface, distance from base of support	Supervised
Single-leg stance while kicking against resistance	Amount of resistance, number of repetitions	Both
Step down with single leg	Surface, height	Supervised
Functional tasks		
Box hop	Direction, pattern	Supervised
Carioca	Speed, distance	Supervised
Figure-of-8		Supervised

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jects read and signed informed consent forms approved by the institutional review board, which also approved the study. Subjects were excluded if they reported any of the following: (1) bilateral ankle instability, (2) history of ankle fracture, (3) ankle injury within 3 months of participation, (4) history of anterior cruciate ligament injury, (5) history of balance disorder, or (6) current participation in supervised physical rehabilitation. Subjects were classified as having CAI if they reported having the following: (1) a history of ankle sprain with pain and/or limping for more than 1 day, (2) chronic weakness, pain, or instability that they attributed to the initial injury, and (3) giving way in the last 6 months.

Survey Completion and Scoring

All subjects completed the FADI and FADI Sport during 3 different sessions (week 1, week 2, and week 7). Separate surveys were completed to reflect the function of the right and left ankles at each session. Subjects were blinded to their previously completed surveys. During this time, 1 subgroup of subjects with CAI (n = 16) participated in a 4-week ankle rehabilitation program.

The FADI has 26 items, and the FADI Sport has 8. Each item is scored from 0 (unable to do) to 4 (no difficulty at all). The 4 pain items of the FADI are scored 0 (none) to 4 (unbearable). The FADI has a total point value of 104 points, whereas the FADI Sport has a total point value of 32 points. The FADI and FADI Sport are scored separately as percentages, with 100% representing no dysfunction.

Rehabilitation

Those subjects assigned to the rehabilitation group attended 6 sessions of supervised rehabilitation throughout 4 weeks. Rehabilitation began during week 3 and continued through week 6. Each session lasted approximately 30 minutes and addressed flexibility, strength, and balance training (Table 2). Balance training included both static and dynamic tasks. Subjects were also given a home exercise program and were told to complete the program 5 times per week. In addition, subjects were instructed to log their compliance. According to the logs, subjects completed the home exercise an average of 3.5 times each week.

Statistical Analysis

Intraclass correlation coefficients (ICCs) using the (2,1) method of Shrout and Fleiss[28] were calculated comparing weeks 1 and 2 and weeks 1 and 7. These were calculated to estimate reliability at 1 and 6 weeks. Separate analyses were run for the involved and uninvolved sides and the CAI control and all CAI groups. These groups were analyzed separately to allow the analysis of reliability throughout 6 weeks. It is not appropriate to analyze reliability throughout 6 weeks among the CAI rehabilitation group, because their scores were not expected to remain the same. An analysis of the healthy group could not be performed because of a lack of variance in the scores among the healthy group (nearly all subjects scored 100%). This lack of variance renders the ICC an inappropriate statistic because of artificial deflation in the ICC value.

Table 3. Estimates of Reliability and SEM

Measure	Group	n	Side	Intraclass Correlation Coefficient (2,1)	SEM
Foot and Ankle Disability Index (1-week interval)	Chronic ankle instability	29	Involved	0.89	2.61
			Uninvolved	0.85	0.82
Foot and Ankle Disability Index (6-week interval)	Chronic ankle instability	25	Uninvolved	0.91	0.64
	Chronic ankle instability control	12	Involved	0.93	1.31
			Uninvolved	0.98	0.43
Foot and Ankle Disability Index Sport (1-week interval)	Chronic ankle instability	29	Involved	0.84	5.32
			Uninvolved	0.94	0.99
Foot and Ankle Disability Index Sport (6-week interval)	Chronic ankle instability	25	Uninvolved	0.67	2.33
	Chronic ankle instability control	12	Involved	0.92	4.43
			Uninvolved	0.92	1.30

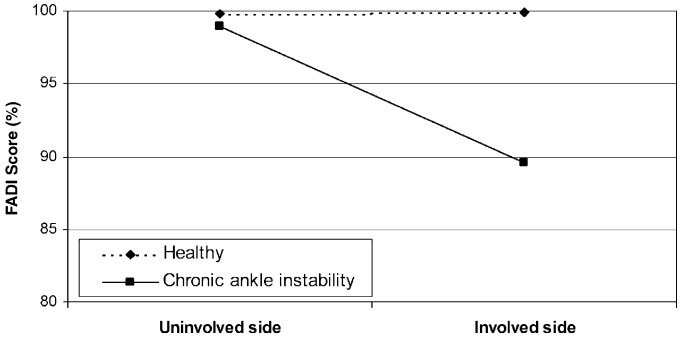

Figure 1. A significant side-by-group interaction ($F_{1,47} = 20.71$, $P < .0005$) was found for the Foot and Ankle Disability Index (FADI) scores. No significant differences between the healthy and chronic ankle instability (CAI) groups were noted for the uninvolved limbs (healthy: 99.8% ± 0.5%, n = 19; CAI: 98.9% ± 2.5%, n = 30). However, the scores for the involved limbs of the CAI group (89.6% ± 9.1%) were significantly less than those for the healthy controls (99.9% ± 0.3%).

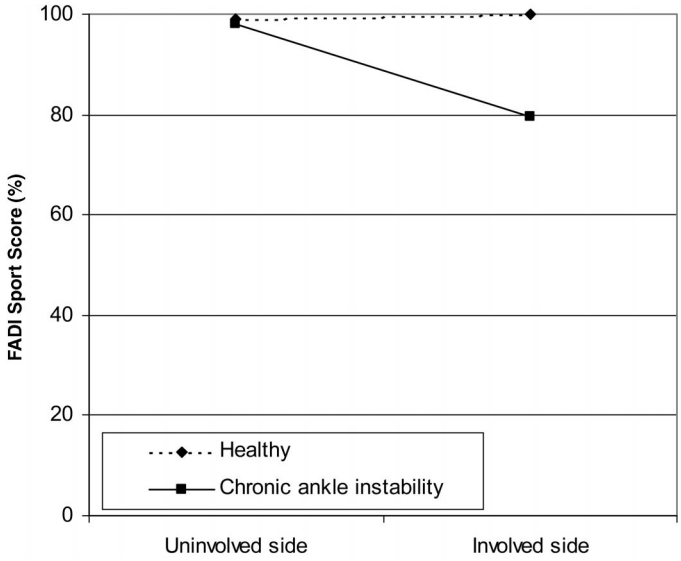

Figure 2. A significant side-by-group interaction ($F_{1,47} = 42.13$, $P < .0005$) was found for the Foot and Ankle Disability Index (FADI) Sport scores. No significant differences were noted between the healthy and chronic ankle instability (CAI) groups for the uninvolved limbs (healthy: 99.2% ± 2.3%, n = 19; CAI, 97.9% ± 4.0%, n = 30). However, the scores for the involved limbs of the CAI group (79.5% ± 12.7%) were significantly less than those for the healthy controls (99.8% ± 0.7%).

To examine the sensitivity of the FADI and FADI Sport to CAI, a 2 × 2 mixed-model analysis of variance was completed. The between-subjects factor was group (healthy or CAI) and the within-subjects factor was side (involved or uninvolved). This comparison was performed at baseline only.

Paired *t* tests were also calculated to identify changes in the involved ankles of the rehabilitation group from week 2 to week 7. To compare the sensitivity to change of the FADI and FADI Sport, effect sizes were calculated for the FADI and FADI Sport. Effect size was calculated as $(\text{mean}_2 - \text{mean}_1)/\text{SD}$, where mean_2 is the posttreatment mean and mean_1 is the pretreatment mean. Lastly, bivariate correlations (Pearson product moment) were computed to identify any relationships between the FADI and FADI Sport scores at baseline. The 3 correlations examined were (1) all CAI subjects, uninvolved side; (2) all CAI subjects, involved side; and (3) healthy subjects, ''uninvolved'' side. The right and left limbs of the healthy subjects were categorized as ''involved'' or ''uninvolved'' to match those of the subjects with CAI.

The significance level for all analyses was set a priori at $P < .05$. The SPSS program (version 10.0; SPSS Inc, Chicago, IL) was used to calculate statistics for this study. Separate analyses were run for the FADI and FADI Sport for all comparisons.

RESULTS

Moderate to good reliability was found at 1-week and 6-week intervals. Data for 29 subjects were analyzed for reliability throughout 1 week (Table 3). Two subjects in the CAI control group had incomplete data at 1 week and were not able to be included in that analysis. Data for 25 subjects were analyzed for reliability throughout 6 weeks. Five subjects failed to return for the final session, and 1 subject had incomplete data.

Significant side-by-group interactions were found for both the FADI ($F_{1,47} = 20.71$, $P < .0005$) and the FADI Sport ($F_{1,47} = 42.13$, $P < .0005$). No side-to-side difference was noted in the healthy group; however, the subjects with CAI reported more dysfunction in the affected ankle than in the unaffected ankle (Figures 1 and 2). The FADI Sport scores were lower than the FADI scores for the involved ankles, sug-

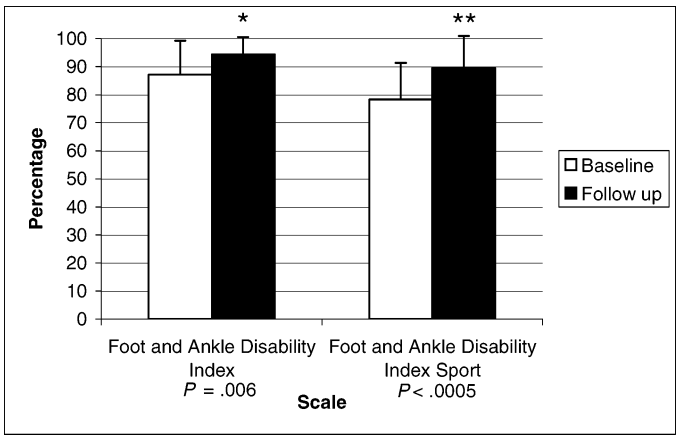

Figure 3. Subjects scored significantly higher on the Foot and Ankle Disability Index after rehabilitation (mean, 94.4% ± 6.1%) than at baseline (mean, 87.1% ± 12.1%). Similar increases were seen in the Foot and Ankle Disability Index Sport (baseline, 78.4% ± 12.9%; follow-up, 89.5% ± 11.3%). *$P < .05$. **$P < .005$.

gesting that the FADI Sport may be more sensitive in detecting impairments associated with CAI. Data for 49 subjects were included in this analysis. Data were incomplete for 1 subject.

The baseline and follow-up scores were significantly different for the FADI ($t = 3.29$, $P = .006$) and FADI Sport ($t = 5.82$, $P < .005$) among the rehabilitation group (Figure 3). Both the FADI and FADI Sport scores improved after rehabilitation. Greater improvement was seen in the FADI Sport scores, suggesting that the FADI Sport (effect size = 0.71) may be more sensitive to change than the FADI (effect size = 0.52). Data for 13 subjects were included in this analysis. Three subjects from the CAI rehabilitation group discontinued participation in the study.

Bivariate correlations demonstrated a significant relationship between the FADI and the FADI Sport. Among all subjects with CAI, the bivariate correlation for FADI and FADI Sport scores for the involved ankle was 0.64. In contrast, the bivariate correlation between baseline FADI and FADI Sport scores that resulted from a combined analysis of the uninvolved extremities of CAI subjects with the matched extremities of healthy subjects was 0.84. The correlation between the baseline FADI and FADI Sport scores was statistically significant ($P < .0005$) among healthy subjects and subjects with CAI. However, when considering the involved limb in the subjects with CAI, only 40% of the variance of one scale is explained by the other. In contrast, 70% of the variance in scores between the scales is related in the healthy subjects. This suggests a clinical difference in the FADI and FADI Sport results among subjects with CAI.

DISCUSSION

The FADI and FADI Sport have strong intersession reliability in subjects with CAI during 1-week and 6-week intervals. The FADI and FADI Sport also appear to be sensitive to deficits associated with CAI. In the healthy subjects, no difference was seen in FADI scores or FADI Sport scores between extremities. However, those subjects with CAI reported significantly more dysfunction in the involved limb than in the uninvolved limb. The FADI Sport appears to be more sensitive at detecting deficits and may be more practical for use among high-functioning individuals. In assessing the sensitivity of these scales, we are not examining the accuracy of these scales as diagnostic tools for determining if subjects do or do not have CAI. Our goal was to determine whether the scales were sufficiently sensitive to detect a functional difference between the groups.

In addition, the FADI and FADI Sport were found to be responsive to improvements in function after rehabilitation. Again, the FADI Sport appears to be more responsive to change than the FADI in the population we studied.

Although the correlation between the baseline FADI and FADI Sport scores for the involved extremities of CAI subjects was statistically significant ($P < .0005$), the degree of association is not high ($r = 0.64$). Thus, these scales appear to measure different functional deficits. The lack of strong correlation may be due to the different purposes of these scales. Although the FADI addresses activities of daily living, the FADI Sport asks about higher-level activities. Commonly, CAI is associated with deficits during athletic or rigorous activity, whereas the completion of low-level tasks is not problematic. Therefore, the weak association between the FADI and FADI Sport results among subjects with CAI is consistent with many clinical presentations of CAI.

Pugia et al[13] began assessing the validity of the FADI and FADI Sport by investigating the correlations among FADI, FADI Sport, ankle girth measures, weight-bearing status, and the Ankle Osteoarthritis Scale after acute ankle sprains. They found no correlation between the functional measures and girth measures. Moderate to good correlations were noted among the functional measures and between the functional measures and weight-bearing status. Despite this initial work examining validity, more researchers need to focus on establishing the validity of the FADI and FADI Sport.

Compared with other instruments, the FADI and FADI Sport are measures specific to the foot and ankle that show promise in quantifying function among a young, active populace with CAI. Although our preliminary study provides support for the use of the FADI and FADI Sport, one must consider the limitations of this study. Only young adult subjects with no history of ankle instability and those with CAI were included. Therefore, one should use caution when considering other patient populations. It is also possible that despite our efforts to keep subjects blinded to their previous reports, those in the rehabilitation group may have experienced a placebo effect. Another limitation of this study was the narrow spectrum of functional limitations found among these subjects. All subjects functioned at a relatively high level at the time of this study.

More research needs to be conducted to evaluate the FADI and FADI Sport in various populations, including older subjects and those with acute injury. As normative values are established through clinical practice and research, it will be important to assess the sensitivity and specificity of the FADI and FADI Sport in detecting pathologic conditions.

In conclusion, we advocate the use of the FADI and FADI Sport self-report instruments in clinical care and research applications in young adults with CAI. These instruments appear to be (1) reliable in detecting functional limitations in subjects with CAI, (2) sensitive to differences between healthy subjects and subjects with CAI, and (3) sensitive to improvements in function after rehabilitation in subjects with CAI.

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